



Description of a cryptic new species of *Cnemaspis* Strauch, 1887 (Squamata: Gekkonidae) from the Western Ghats of Kerala State of India

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Abstract

We describe a cryptic new species of gecko of the genus *Cnemaspis* Strauch from the southern Western Ghats of Kerala. This medium-sized *Cnemaspis* species is differentiated from all other Indian congeners by a suite of the following distinct morphological characters: heterogeneous mid-dorsal scales, 6–7 supralabials; 113–120 paravertebral rows of tubercles; 71–85 mid-dorsal scales; absence of spine-like tubercles on flanks; subimbricate, smooth ventral scales; 135–140 mid-ventral scales; subdigital lamellae under fourth digit of manus 23–25; subdigital lamellae under fourth digit of pes 24–25; males with 7–8 preloacal pores; median row of subcaudals enlarged, smooth, a series of two large scales alternating, containing one divided scale; head and neck colouration brownish-yellow, consistent in adult males; adult females with orange coloured head and neck. Recent new descriptions of *Cnemaspis* species together with the present discovery show that the southern Western Ghats species have been overlooked by previous studies. Therefore we suggest further studies to evaluate the diversity of *Cnemaspis* in this region.

Key words: Day-gecko, lizard, *Cnemaspis ornata*, southern Western Ghats

Introduction

The Indian subcontinent is one of the 12 mega-diversity centers of the world within which the Western Ghats and the Eastern Himalayan region constitute 2 of the 25 biodiversity hotspots. As such, the Western Ghats is widely known as a region harboring a high diversity of endemic flora and fauna (Myers, 1988; Myers *et al.* 2000). Recent discoveries of amphibians have led to more than 120 new species descriptions (Biju & Bossuyt 2009; Biju *et al.* 2014; Gururaja *et al.* 2014; Vijayakumar *et al.* 2014; Abraham *et al.* 2015; Dinesh *et al.* 2017), however, the diversity in reptiles still remain unexplored (Giri 2008; Giri & Bauer 2008).

The genus *Cnemaspis* Strauch, 1887 is one of the most diverse genera of the family Gekkonidae. The genus is presently considered to be distributed in tropical Africa, South and Southeast Asia. Although similar in their superficial morphology, molecular phylogenetic analyses of this genus from Africa, South Asia, and Southeast Asia show that *Cnemaspis* species in these regions do not form a monophyletic group and are not particularly closely related to each other (Gamble *et al.* 2012; Pyron *et al.* 2013; Zheng & Wiens 2016). South Asian and African members of the genus will probably soon require taxonomic revisions (Sayyed *et al.* 2018). The number of species in the genus has now grown rapidly; there are now over 146 recognized species (Uetz & Hallermann 2019), including 38 species known from the Indian mainland (Cyriac & Umesh 2013; Mirza *et al.* 2014; Cyriac & Umesh 2014; Srinivasulu *et al.* 2015; Sayyed *et al.* 2016; Cyriac *et al.* 2018; Sayyed *et al.* 2018; Khandekar 2019; Khandekar *et al.* 2019). An additional 23 species are known from Sri Lanka, all endemic to the island (Manamendra-Arachchi *et al.* 2007; Wickramasinghe & Munindradasa 2007; Vidanapathirana *et al.* 2014; Wickramasinghe *et al.* 2016; Batuwita & Udugampala 2017). As a result of this diversity, *Cnemaspis* is the second most species-rich gecko genus in the Old World (Grismer *et al.* 2014).

Cnemaspis is characterized by having slender digits with recurved clawed; two distal phalanges which are com-

pressed, forming an angle with the basal portion of the digits, the lower surface having rows of plates; body more or less depressed; scales granular or tubercular above; tail is more or less cylindrical; pupils rounded; eyelid distinct all around the eye; males with or without preloacal or femoral pores; a well developed hypoischium, post-anal bones and sacs, and a reduced hyoid apparatus, with only one pair of basibranchials; the presence of three or four sternal ribs; interclavicles well developed and cruciform (in the Oriental species) or much reduced and with only a very small transverse arm (in the African species); adhesive toe pads absent (in the Oriental species) or present (in the African species); leaf toes and paraphalanges absent, having diurnal habits predominantly (Smith 1935; Gamble *et al.* 2012). A few species of the *Cnemaspis* group are arboreal and ground-dwelling; their cryptic morphology and colouration contributes to their camouflage (Grismer *et al.* 2014; Wood *et al.* 2017).

Comprehensive taxonomic revision of the genus *Cnemaspis* in India remains elusive because of the lack of sampling and detailed descriptions of some species in the past. Consequently, there is confusion in the identity of some Indian *Cnemaspis* described prior to 1984: detailed descriptions, type localities and distributions of most of the geckos within this genus have yet to be fully confirmed and properly documented (e.g., *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda, *C. boiei* Gray, *C. jerdonii* Theobald, *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda, *C. nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, and *C. ornata* Beddome).

We have focused our current study on *Cnemaspis ornata*. We have examined the lectotype and series of paralectotypes at the Natural History Museum, London (NHMUK), conducted field surveys and documented our observations at Tirunelveli, Tamil Nadu which is the type locality of *C. ornata*. Additional field collections of *C. ornata*-like geckos from Thenmala, Kerala State revealed that presence of an undescribed species of *Cnemaspis*. Thus, here we describe this new species of *Cnemaspis* from the lower elevation of the southern Western Ghats of Kerala.

Materials and methods

Methodology. Scale counts and external observations of morphology were made using a Lensele stereo microscope. Colour characters were taken from digital images of live specimens on field. The type specimens of the new species discussed in this paper were collected from the Thenmala, Kerala State. Specimens were hand collected, photographed in life, then euthanized following George (1973), fixed in formalin, and preserved in 70% ethanol. The materials referred to this study are deposited in the collection of the Bombay Natural History Society (BNHS), Mumbai (Permit to RD, numbers WL10-41691/2014 and 94/2009/ & WLD). Additional field surveys were carried out in Ponmudi Hill, Kerala and parts of Tirunelveli in Tamil Nadu. We examined 96 specimens of the new species and 18 specimens of *Cnemaspis ornata* (specimens not collected); additionally we examined all the previously described Indian species in the collection of the Natural History Museum, London (NHMUK), Zoological Survey of India (ZSI WRC), Akurdi Pune, Maharashtra, Bombay Natural History Society (BNHS) and Zoological Survey of India, Western Ghats Regional Center (ZSI-WGRC), Kozhikode, Kerala, also the type series of *C. ornata*: lectotype NHMUK 74.4.29.400, and paralectotypes, NHMUK 74.4.29.401, NHMUK 74.4.29.402, NHMUK 74.4.29.403, NHMUK 74.4.29.404, NHMUK 74.4.29.405, NHMUK 74.4.29.406, NHMUK 74.4.29.407, NHMUK 74.4.29.408, NHMUK 74.4.29.409.

Morphometric characters. The following measurements were taken with both a Yamayo digimatic calliper and Tesacalip 64 (to the nearest 0.01 mm): snout vent length (SVL), from tip of snout to anterior edge of cloacal opening; trunk length (TRL), distance from axilla to groin measured from posterior edge of the forelimb insertion to the anterior edge of the hind limb insertion; trunk width (TW), maximum width of body; tail length (TL), from vent to tip of tail; tail width (TLW), measured at widest point of tail; head length (HL), distance between retroarticular process of jaw and snout-tip; head width (HW), maximum width of head; head depth (HD), maximum depth of head, from occiput to underside of jaws; forearm length (FL), from base of palm to elbow; tibia length (TBL), knee to tarsus; palm length (PAL), distance between posterior-most margin of palm and tip of longest finger; eye to nares distance (E-N), distance between anterior most point of eye and nostril; eye snout to distance (E-S), distance between anterior most point of eye and tip of snout; eye to ear distance (E-E), distance from anterior edge of ear opening to posterior corner of eye; ear length (EL), maximum distance end to end of ear opening; distance between nares (IN), right to left nare; orbital diameter (OD), greatest diameter of orbit; inter orbital snout distance (IO), distance between orbits on frontal bone.

Meristic characters. The following meristic characters were recorded: number of supralabial scales (SupL) and infralabial scales (InFL) for both left (L) and right (R) sides, between the first labial scale and the gape; number of interorbitals (InO), scales between eyes; number of postmentals (PoM), surrounded by the posterior-postmentals, infralabials and the mental; number of posterior postmentals (PoP), scales that are postmental-bounded between infralabials; number of supranasal (SuN), scales between naris; number of the postnasal (PoN), scales posterior to the naris; number of supraciliaries (SuS), scales above the eye; number of scales between eye to tympanum (BeT), from posterior-most point of the orbit to anterior-most point of the tympanum; number of canthal scales (CaS), number of scales from posterior-most point of naris to anterior most point of the orbit; number of dorsal paravertebral scales (PvS), between pelvic and pectoral limb insertion points along a straight line immediately left of the vertebral column; number of mid-dorsal scales (MbS), from the centre of mid-dorsal row diagonally towards the ventral scales; number of midventral scales (MvS), from the first scale posterior to the mental to last scale anterior to the vent; number of mid-body scales (BIS), across the ventral between the lowest rows of dorsal scales; precloacal pores (PaPores), anterior to the cloaca; lamellae under digits of manus (MLam) and pes (PLam) for right (R) sides, counted from first proximal enlarged scensor greater than twice width of the largest palm scale, to distalmost lamella at tip of digits; lamellae under fourth digit of pes (Lamp fourth). For the geographical coordinates, altitude, and for temperature readings, we used a Kestrel 4500 receiver.

Hierarchical Cluster Analysis. In order to determine whether the new species is morphometrically differentiated from similar *Cnemaspis* species, Hierarchical Cluster Analysis was performed in PAST v. 3.25 (Hammer *et al.* 2001) using Ward's Method with Euclidean Distances. The analysis included nine specimens representing a subset of five *Cnemaspis* species including the new species, *C. ornata*, and three additional recently described species. The characters for which any morphometric analysis was lacking were removed from final analysis leaving 16 characters for the analysis; the characters TL and PAL were removed from final analysis. Measurements were size corrected by using the ratio of each character to SVL. The columns containing variables were subjected to resampling by bootstrapping for 1000 times.

Results

Morphometric data of all adult specimens of the new species were compared to *C. ornata*, lectotype NHMUK 74.4.29.400 (Table 1). Morphometric measurements showed significant differences between *Cnemaspis aaronbaueri* **sp. nov.** and *C. ornata*. Snout vent length (SVL), trunk length (TRL), head length (HL), forearm length (FL), tibia length (TBL), palm length (PAL), eye to nares distance (E-N), eye snout to distance (E-S) and eye to ear distance (E-E), were all comparatively longer in *C. ornata*; head width (HW), trunk width (TW) and tail width (TLW) narrower in the new species; head depth (HD) 60% less in the new species; ear length (EL) 41% extended and orbital diameter (OD) 71% wider in *C. ornata*. Morphological characters differentiate the new species from *C. ornata* based on the description given in Smith (1935). *Cnemaspis aaronbaueri* **sp. nov.** is distinguished from *C. ornata* by being grey in colour on the body dorsally (*versus* brown in *C. ornata*); ventral parts of the head, body, limbs and tail whitish-grey (*vs.* pale brownish); tail un-patterned, grey with white and black small spots (*vs.* white and black annuli); streak not present on throat (*vs.* dark streak on throat); white eye shape mark edged with black on the shoulder present in *C. ornata* whereas missing in *Cnemaspis aaronbaueri* **sp. nov.** new species was mistakenly associated with *C. ornata* previously. In the Hierarchical Cluster Analysis all specimens were grouped in their respective distinct sub-clusters with high bootstrap support (> 80%) except *Cnemaspis ornata*, the cluster for which was supported by bootstrap value of 69. The sub-cluster containing *C. aaronbaueri* **sp. nov.** and *Cnemaspis agarwali* also had low support with bootstrap value of 30 (Fig. 1).

Systematics

Cnemaspis aaronbaueri **sp. nov.**

Figs. 2–5

Holotype. BNHS 2607, an adult male, 34.57 mm SVL, collected from one meter above ground on a stone compound wall of a tea estate in Thenmala, (8.959972°N, 77.07517°E), elevation about 218 m, in the Kollam District of Kerala State; collected on 01 February 2017 by Amit Syyed and Abhijit Nale.

Paratype. BNHS 2608, an adult male, 34.28 mm SVL, and BNHS 2609 an adult female, 32.85 mm SVL; collected from the stone at the same locality as the holotype on 02 January 2016 by Amit Sayyed and Abhijit Nale.

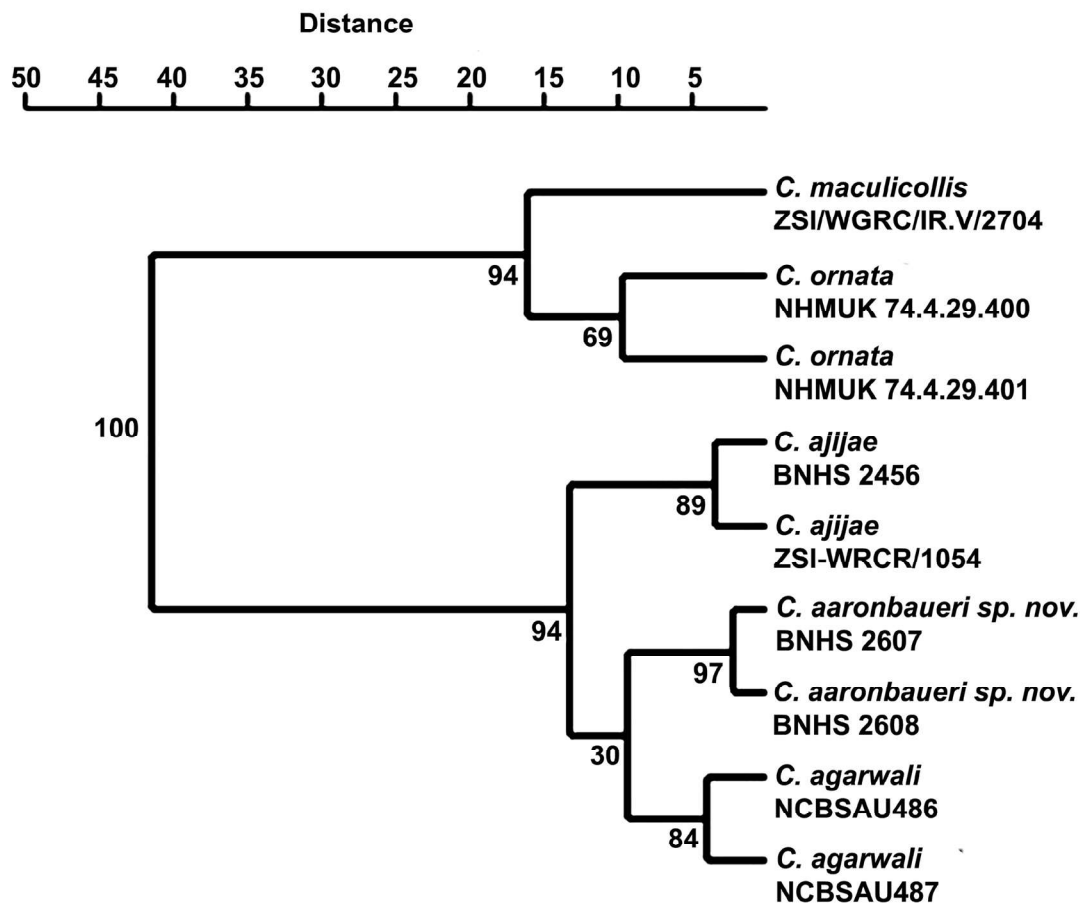


FIGURE 1. Hierarchical Cluster Analysis tree for subgroup of *Cnemaspis* specimens using Ward's method. Scale shows Euclidean distances. Numbers at the node are bootstrap values.

Diagnosis. *Cnemaspis aaronbaueri* sp. nov. differs from all other Indian species of *Cnemaspis* by having the following characters: adult males reaching 34.57 mm SVL, adult females reaching 32.85 mm SVL; 6–7 supralabials; 6–7 infralabials; dorsal scales heterogeneous with small raised granules intermixed with randomly arranged weakly carinate, large tubercles; scales on lower flank slightly smaller than dorsum; 113–120 paravertebral tubercles; 71–85 mid-dorsal scales; spine-like tubercles absent on flanks; ventral scales smooth, imbricate; 135–140 midventral scales; 31–33 transverse scales across belly; subdigital lamellae under fourth digit of manus 23–25, under fourth digit of pes 24–25; males with 7–8 precloacal pores; Tail cylindrical, single small post-anal spur on each; dorsal scales on tail small, juxtaposed granules, intermixed with slightly enlarged, carinate tubercles; subcaudals on median row enlarged, smooth, series of two large scales alternating with one divided scale. Dorsal colour of head and neck brownish-yellow consistently in adult males; females with orange coloured head and neck.

Comparisons. *Cnemaspis aaronbaueri* sp. nov. differs from all other Indian congeners by the following characters: mid-dorsal scales heterogeneous (*versus* homogenous in *C. adii* Srinivasulu, Kumar & Srinivasulu, *C. boiei* (Gray), *C. indica* (Gray), *C. jerdonii* (Theobald), *C. kolhapurensis* Giri, Bauer & Gaikwad, *C. littoralis* (Jerdon), *C. mysorensis* (Jerdon), *C. nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, *C. sisparensis* (Theobald), *C. wynadensis* (Beddome)). The new species is distinguished from the following species by lacking spine-like tubercles on flanks (*versus* spine-like tubercles present on flanks): *C. assamensis* Das & Sengupta, *C. andersonii* (Annan-dale), *C. amboliensis* Sayyed, Pyron & Dileepkumar, *C. gracilis* (Beddome), *C. goensis* Sharma, *C. indraneildasii* Bauer, *C. jerdonii*, *C. littoralis*, *C. mysorensis*, *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda, *C. nilagirica*, *C. otai* Das & Bauer and *C. wicksii* (Stoliczka). *Cnemaspis aaronbaueri* sp. nov. has 7–8 precloacal pores and lacks femoral pores which differentiates it from the following species: by presence of precloacal and femoral pores: *C. adii*, *C. amboliensis*, *C. andersonii*, *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda, *C.*

gracilis, *C. goaensis*, *C. indraneildasii*, *C. mysoriensis*, *C. otai*, *C. shevaroyensis* Khandekar, Gaitonde & Agarwal, *C. wicksii* (Stoliczka), *C. yercaudensis* Das & Bauer; and from the following species by presence of only femoral pores in *C. agarwali* Khandekar, *C. ajijae* Sayyed, Pyron & Dileepkumar, *C. anaikattiensis* Mukherjee, Bhupathy & Nixon, *C. flaviventralis* Sayyed, Pyron & Dahanukar, *C. girii* Mirza, Pal, Bhosale & Sanap, *C. heteropholis* Bauer, *C. indica*, *C. jerdonii*, *C. kotiyoorensis* Cyriac & Umesh, *C. limayei* Sayyed, Pyron & Dileepkumar, *C. littoralis*, *C. mahabali* Sayyed, Pyron & Dileepkumar, *C. sisparensis* (Theobald), *C. thackerayi* Khandekar, Gaitonde & Agarwal, and *C. wynadensis* (Beddome). The new species is differentiated from the following species by having 7–8 precloacal pores: two precloacal pores in *C. anamudiensis* Cyriac, Johny, Umesh & Palot, presence of a continuous series of 24–28 precloacal and femoral pores in *C. kolhapurensis* Giri, Bauer & Gaikwad, absence of both femoral and precloacal pores in *C. assamensis*. The new species differs from *C. beddomei* (Theobald) and *C. maculicollis* Cyriac, Johny, Umesh & Palot by having SVL less than 35 mm (*versus* 50.6 mm in *C. beddomei* and 43 mm in *C. maculicollis*). The new species can be easily confused with *C. nairi* but can be distinguished by having a shorter SVL 34.57 mm (*versus* SVL 41.0 mm); 6–7 supralabials, 6–7 infralabials (*versus* 8 supralabials, 7–9 infralabials); dorsal scales small, granular, raised, intermixed with slightly carinate, randomly arranged tubercles (*versus* SVL 41.0 mm back with small conical scales, intermixed with larger conical or rounded tubercles, arranged in 12 rows); ventral scales of the body smooth, imbricate (*versus* ventrals smooth, rounded); dorsal ground colour of tail grey, un-patterned, bearing white and black small spots (*versus* tail ringed with black and olive yellow).

TABLE 1. Mensural data for the type series of *Cnemaspis aaronbaueri* sp. nov. and *Cnemaspis ornata* (regenerated tail=*).

Measurements	<i>Cnemaspis aaronbaueri</i> sp. nov.			<i>Cnemaspis ornata</i>
	Holotype	Paratypes		Lectotype
	BNHS 2607	BNHS 2608	BNHS 2609	NHMUK 74.4.29.400
Sex	male	male *	female	male
SVL	34.57	34.28	32.85	42.57
TRL	13.99	13.91	12.92	15.83
TW	7.14	6.24	6.80	8.91
TL	45.03	41.56	42.70	-
TLW	3.36	3.14	2.83	5.00 (broken)
HL	5.78	5.63	5.82	8.63
HW	5.93	6.20	6.04	9.07
HD	3.95	4.04	3.83	6.49
FL	5.29	5.47	5.71	8.08
TBL	6.43	6.50	5.76	8.88
PAL	5.24	5.06	4.45	5.90
E–N	3.18	3.17	3.24	3.48
E–S	4.09	4.08	4.18	4.39
E–E	2.81	2.70	2.91	3.82
EL	0.45	0.39	0.39	1.09
IN	1.20	1.08	1.19	1.64
OD	1.84	1.73	1.82	2.59
IO	3.11	3.55	3.94	05.13
HL as % of SVL	16.8%	16.5%	17.8%	20.3%
HW as % of SVL	17.2%	18.1%	18.4%	21.4%
HD as % of HL	68.4%	71.8%	65.9%	75.3%
E–S as % of HL	70.8%	72.5%	71.9%	50.9%
OD as % of HL	31.9%	30.8%	31.3%	30.1%
EL as % of HL	7.8%	6.92%	6.8%	12.7%
TRL as % of SVL	40.5%	40.6%	39.4%	37.2%
FL as % of SVL	15.4%	16.0%	17.4%	19%
TBL as % of SVL	18.6%	19.0%	17.6%	20.9%
TL as % of SVL	130.3%	121.3%	130.0%	-

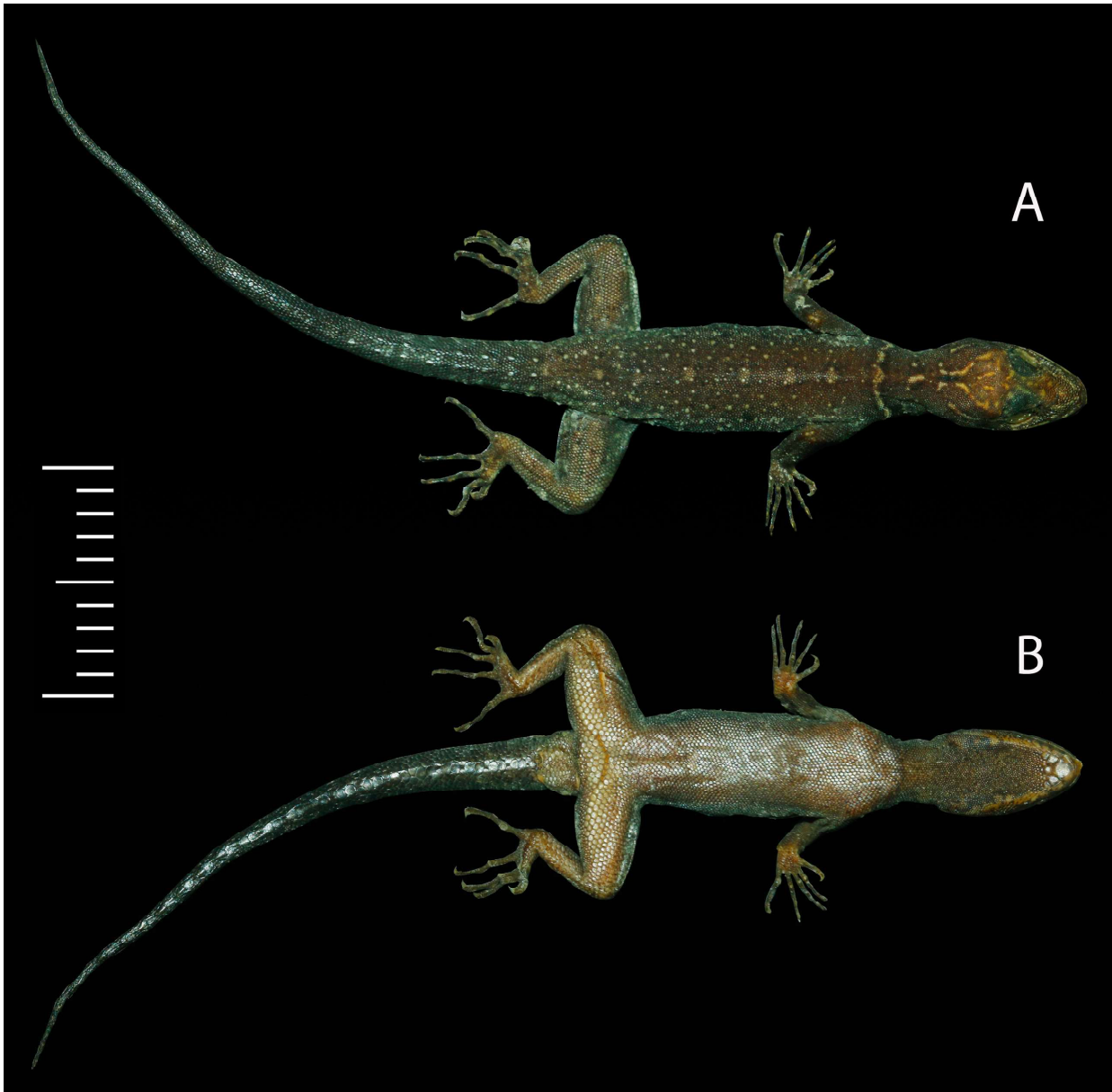


FIGURE 2. Holotype of *Cnemaspis aaronbaueri* sp. nov. A. dorsal view; B. ventral view.

Cnemaspis aaronbaueri sp. nov. closely resembles *C. ornata* (Beddome) and *C. agarwali* Khandekar. However, it can be distinguished from both species by the presence of 6–7 supralabials (versus 6–9 in *C. ornata*; 5–9 *C. agarwali*); 6–7 infralabials (versus 6–9 in *C. ornata*; 7–9 in *C. agarwali*); SVL 35.0 mm (versus SVL 42.0 mm in *C. ornata*; 33.0 mm in *C. agarwali*); absence of femoral pores (versus presence of femoral and precloacal pores in *C. agarwali*); two pairs of postmentals, five large scales posteriorly surrounded to middle chin shield (versus three pairs of postmentals, small scales posteriorly surrounded to middle chin shield in *C. ornata*; absence of middle chin shield in *C. agarwali*); dorsal scales arranged in 12 longitudinal rows (versus 16 longitudinal rows in *C. ornata*; 12–17 in *C. agarwali*); paravertebral scales 113–120 (versus 110 in *C. ornata*; 107 in *C. agarwali*); ventral scales of the body smooth, imbricate (versus smooth, rounded in *C. ornata*; smooth, subimbricate, slightly rounded in *C. agarwali*); midventral scales 135–140 (versus 151 in *C. ornata*; 105 in *C. agarwali*); tail covered above with small, juxtaposed granules, intermixed with slightly enlarged, carinate tubercles (versus small, subimbricate and series of large pointed tubercles in *C. ornata*; larger, flatter, subimbricate posteriorly, intermixed with slightly enlarged, strongly keeled, conical tubercles forming whorls in *C. agarwali*).

Description of holotype. Adult male; SVL 34.57 mm; (unless otherwise stated, morphometric data are given as % of SVL) head moderately short (HL 16.8%), narrow (HW 17.2%), flat (HD as % of HL 68.4%), distinct from neck; snout short (E–S as % of HL 70.8%), curved laterally; scales on snout granular, smooth, larger than those on

the forehead and interorbital region; eye small (OD as % of HL 31.9%); pupil rounded; eighteen supraciliaries; 27 interorbital scales; ear opening oval, small (EL as % of HL 7.8%); 21 scales between eye and tympanum; rostral concave, dorsally about 50% divided by a longitudinal groove; rostral bordered posteriorly by two supranasals; nostrils small, bordered posteriorly by three small, granular, postnasal scales; mental large, triangular, posteriorly not pointed, broader than long, bordered posteriorly by two broadly separated postmentals and a single, large intermediate chin shield; five large, smooth scales posteriorly surrounded to intermediate chin shield; gular scales granular, smaller than those on throat.



FIGURE 3. A. dorsal of the head; B. lateral of the head; and C. ventral view of the head and arrangement of posterior scales and middle chin shield of *Cnemaspis aaronbaueri* sp. nov. D. dorsal of the head; E. lateral of the head; and F. ventral view of the head of *Cnemaspis ornata* Lectotype NHMUK 74.4.29.400.

Body slender (TRL 40.5%); dorsal scales small, granular, raised, equal in size throughout body, intermixed with randomly arranged, slightly carinate, larger tubercles which are slightly pronounced towards the posterior end; tubercles extend from the dorsal part of hind limb insertion to base of tail; scales on lower flank slightly smaller than dorsal; scales on forehead and neck region slightly smaller than those on dorsal body; 113 paravertebral scales; 71 mid-dorsal scales; 135 midventral scales, smooth, flat, cycloid, slightly larger than dorsals; forelimbs fairly long (FL 15.4%), slender; dorsal scales of brachium granular, smooth; hind limbs slightly longer than forelimbs (TBL 18.6%); dorsal scales of forearm granular, smaller than brachium; ventral scales of brachium raised; ventral scales of forearm smooth, small, raised; dorsal scales on palm, foot and fingers smooth, cycloid; scales on palmar and plantar surface smooth, raised and juxtaposed; lamellae on metacarpals fragmented; subdigital lamellae on finger I: 15, finger II: 16, finger III: 23, finger IV: 23, finger V: 19; toe I: 12, toe II: 19, toe III: 24, toe IV: 24 and toe V: 24. Relative length of digits, fingers: IV (3.95 mm) > V (3.62 mm) III > (3.56 mm) > II (3.33 mm) > I (1.41 mm); toes: V (4.39 mm) > IV (3.88 mm) > III (4.10 mm) > II (3.05 mm) > I (0.88 mm). Eight precloacal pores and no femoral pores; scales on precloacal and femoral region larger than those on abdominal and juxtaposed. Tail long (TL 130.3%), cylindrical, base slightly swollen; one small post-cloacal spur on each side of lateral surface of hemipenial bulges at base of tail;

dorsal scales of tail small, juxtaposed, intermixed with slightly enlarged, keeled tubercles; median subcaudals row enlarged, smooth, median series of two large widened scales alternating with one divided scale.

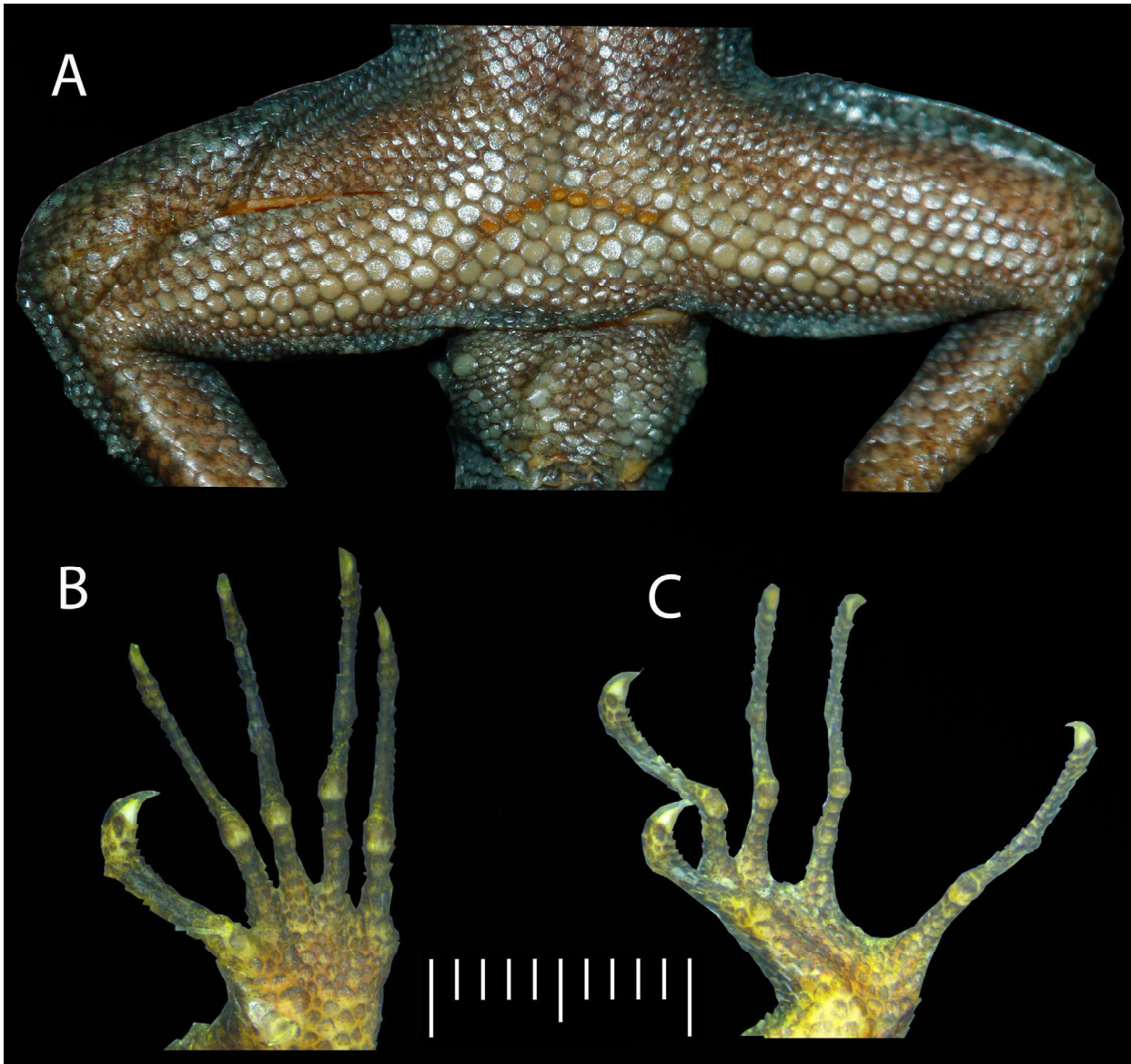


FIGURE 4. A. precloacal pores; B. lamellae under meniscus; C. lamellae under pes of *Cnemaspis aaronbaueri* sp. nov.

Colouration in life (Figs. 6 A–D). Adult male's dorsal ground colour of head and neck brownish-yellow; dorsal colour of trunk, hind limbs, forelimbs and tail grey. Dorsum of body with six pairs of black spots extending to sacral region; behind each black spot a white colour spot; dorsal vertebral spots larger than those on other parts of the body; large black oval patch on both sides of the flank present in a few males; lighter white mottling on limbs; black and white spots on dorsal surfaces on phalanges. Supralabials and infralabials yellow. Four yellow stripes on lateral surface of head. The uppermost short postorbital stripe extends onto the posterior dorsal surface of head. Below it is a long stripe starting from nares and running through canthal region behind eye to occiput area. The third extends from just above the ear opening toward rostral including the supralabials. The lowest stripe begins on the lateral part of the lower neck and extends to the inner part of the jawbone including the mental and continues on to the other side of the lower neck. Two or three scattered yellow spots on the dorsum of neck; "Y" shaped yellow marking on the occiput, an oval black spot present on the fork of "Y" shaped marking; scattered yellow spots on interorbital and snout region; a transverse black and white confluent band on neck. Pupil black, rounded, surrounded by orange; ventral side of head, body, limbs and tail dusky white. Adult female's dorsal ground colour of head and neck orange; overall dorsal patterning on head, neck and colouration on the ventral side is the same as in males; two cream-yellow stripes on the lateral sides of head, one begins from occiput to posterior edge of the eye, lower from ear opening

to postlabials. Dorsal ground colour of trunk, hind limbs, forelimbs and tail brown; larger, oval-shaped black and yellow spots present on dorsal body; thin cream-white transverse bands with black spots on phalanges. Subadult colouration more or less similar to the adult female. Juvenile dorsal colouration differs from adults and subadults, consisting of dark brown body colour with a broad light yellow paravertebral stripe; tail reddish brown (Fig. 6 C).

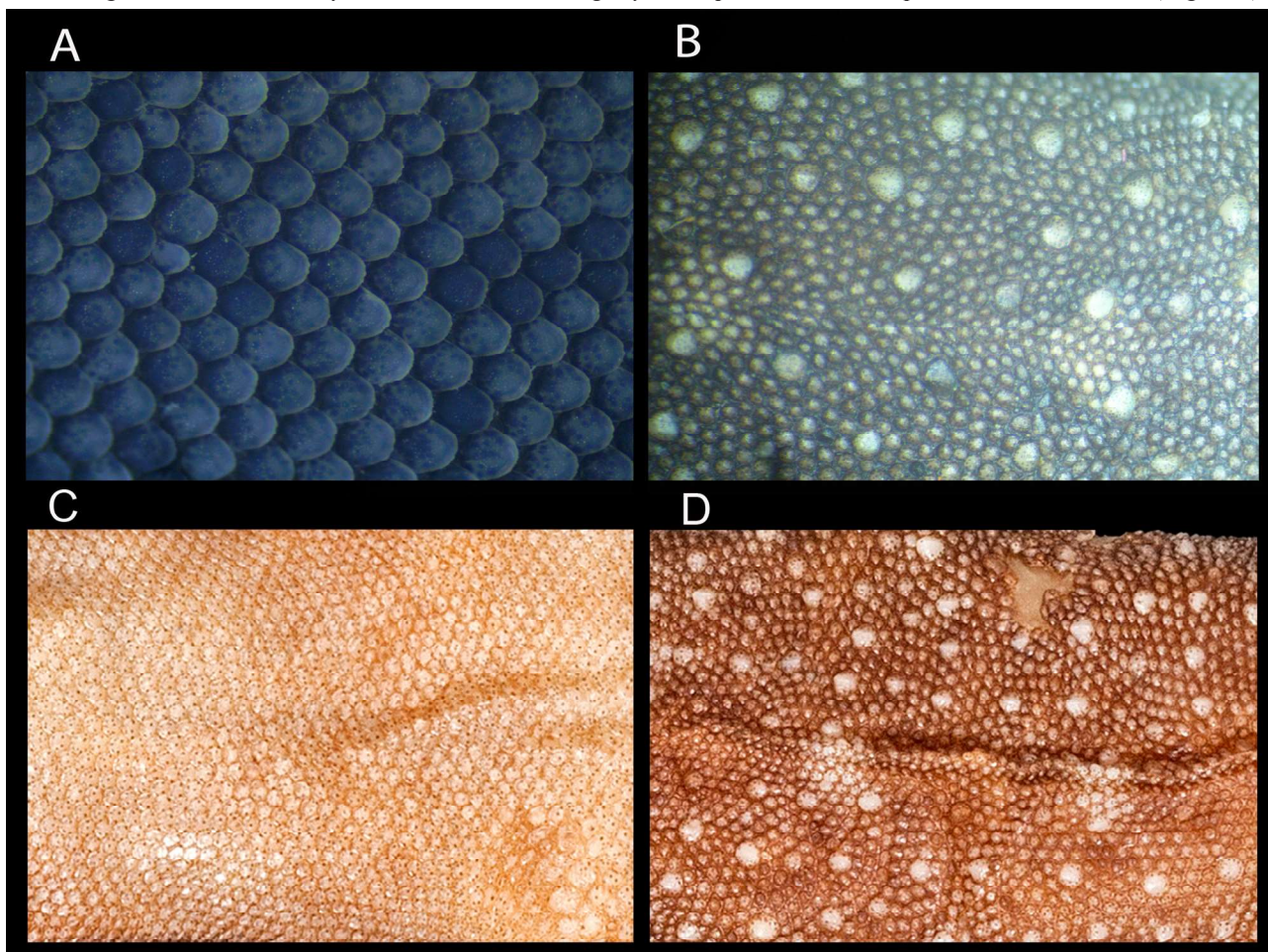


FIGURE 5. Pholidosis of *Cnemaspis aaronbaueri* **sp. nov.** A. ventral view; B. dorsal view; and C. ventral view; D. dorsal view of *Cnemaspis ornata*.

Colouration in preservative (Fig. 2 A, B). Ground colour of upper head dark brown with turmeric yellow markings on occiput, interorbital and snout region; ground colour of dorsal body and limbs brown with vertebral spots, neck band and bands on sides of head grey. Underside of head, abdomen and limbs are yellowish in colour. Overall colouration of the tail dark grey.

Variation. Overall colouration of male paratype resembles the holotype. Female colouration is the same, except for orange colour head and neck, dorsal ground colour of trunk, hind limbs, forelimbs and tail brown in females whereas those areas are grey in males. Morphometric and scalation variation are presented in Table 2.

Etymology. The specific epithet is a patronym, honouring Professor Dr. Aaron M. Bauer of Villanova University, USA for his contributions to herpetology.

Distribution. According to our observations *Cnemaspis aaronbaueri* **sp. nov.** is distributed in parts of Tirunelveli, Tamil Nadu, and Thenmala, Kollam District of Kerala (the type locality; Fig. 7A).

Natural History. The type series were found on a stone compound wall of a tea estate at Thenmala (Fig. 7B), in the Kollam District of Kerala State. Around the type locality the following vegetation and plantations were observed: tea, rubber and evergreen forests. Remnant natural habitats serve as refuge for diverse flora and fauna in the region. The following geckos were found in sympatry with the new species at the type locality: *Cnemaspis* cf. *nairi* and an undescribed species of *Hemidactylus*.



FIGURE 6. colour in life of *Cnemaspis aaronbaueri* sp. nov. A. holotype male; B. paratype female; C. juvenile; D. sub-adult.

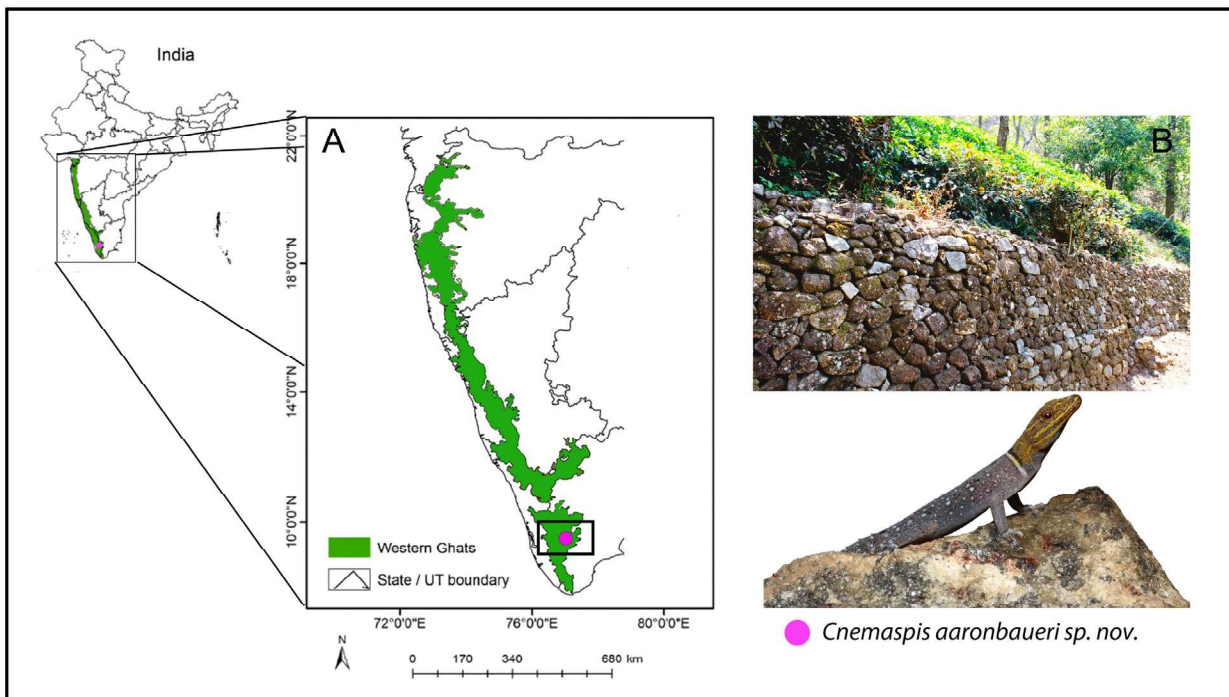


FIGURE 7. Map of India depicting the study region. A, Inset shows the map of Western Ghats of India with the rectangular box showing the type locality, B. habitat of *Cnemaspis aaronbaueri* sp. nov.

TABLE 2. Morphometric and meristic data of the holotype and two paratypes of *Cnemaspis aaronbaueri* **sp. nov.**, *Cnemaspis ornata* and *Cnemaspis maculicollis*.

Character	<i>Cnemaspis aaronbaueri</i> sp. nov. , Holotype	<i>Cnemaspis aaronbaueri</i> sp. nov. , Paratype	<i>Cnemaspis aaronbaueri</i> sp. nov. , Paratype	<i>Cnemaspis ornata</i>	<i>Cnemaspis maculicollis</i>
Specimen No.	BNHS 2607	BNHS 2608	BNHS 2609	NHMUK 74.4.29.400	ZSI/WGRC/IR.V/ 2704
Sex	male	male	female	male	male
SupL R/L	6/6	7/7	7/7	8/9	7/7
InfL R/L	7/6	7/6	7/7	8/9	8/8
InO	28	29	28	43	39
PoM	5	4	5	8	8
PoP	13	13	13	11	12
SuN	2	2	2	2	2
PoN	3	3	3	2	2
SuS	18	18	17	21	20
BeT	21	21	22	24	23
CaS	13	12	12	16	15
PvS	113	115	120	110	112
MbS	71	72	85	66	56
MvS	135	136	140	151	156
BIS	31	32	33	29	32
PaPores	8	7	-	6	10
MLam R	15–16–23–23–19	15–17–23–23–19	15–17–23–25–20	21–21–28–29–22	15–18–20–20–18
PLam R	12–19–24–24–24	12–20–24–24–24	12–20–25–25–23	14–23–28–30–27	15–17–24–23–22

TABLE 3. Morphometric and meristic data of paralectotypes of *Cnemaspis ornata* (bands present=*, un-patterned= #).

Paralectotypes	SVL	TRL	TW	TL	SupL R/L	InfL R/L	MLam R IV digit	PLam R IV digit	PaPores
NHMUK 74.4.29.401 (adult male)	44.06	15.58	9.99	46.01*	8/9	7/8	29	28	7
NHMUK 74.4.29.405 (adult female) poor specimen	38.68	16.12	8.89	27.02#	7/7	7/7	23	25	damage
NHMUK 74.4.29.403 (adult male)	38.53	16.49	8.00	39.07#	7/7	6/7	23	25	8
NHMUK 74.4.29.404 (Juvenile female)	25.52	7.92	6.13	19.21*	8/8	8/8	28	30	-
NHMUK 74.4.29.402 (Juvenile female),	26.12	9.56	6.80	broken	9/9	8/8	28	29	-
NHMUK 74.4.29.406 (Juvenile female)	27.44	9.36	5.45	missing	8/8	8/7	29	29	-
NHMUK 74.4.29.407 (Juvenile female)	25.22	8.77	5.80	26.85*	9/8	7/8	29	30	-
NHMUK 74.4.29.408 (Juvenile female)	27.70	9.39	6.99	missing	8/8	8/8	28	29	-
NHMUK 74.4.29.409 (juvenile female)	23.51	8.73	5.53	missing	9/9	8/8	29	damaged	-

Discussion

In recent years the number of new species descriptions and phylogenetic uniqueness of lineages has led to the suggestion that the Western Ghats of India have an exceptional diversity of reptiles and amphibians (e.g., Mana-

mendra-Arachchi *et al.* 2007; Giri *et al.* 2009; Smith *et al.* 2012; Biju *et al.* 2014; Deepak *et al.* 2016; Agarwal *et al.* 2016; Garg & Biju 2017). This has drawn the attention of biologists which has spurred further efforts of documenting, describing and revising the flora and fauna of this region (e.g., Joshi & Edgecombe 2013; Abraham *et al.* 2015; Hareesh *et al.* 2015; Robin *et al.* 2017). In these recent years 17 new species of the genus *Cnemaspis* have been described from India (Manamendra-Arachchi *et al.* 2007; Giri *et al.* 2009; Cyriac & Umesh 2014; Mirza *et al.* 2014; Srinivasulu *et al.* 2015; Sayyed *et al.* 2016; Cyriac *et al.* 2018; Sayyed *et al.* 2018; Khandekar 2019; Khandekar *et al.* 2019) of which eight are known from the northern Western Ghats (Sharma 1976; Giri *et al.* 2009; Mirza *et al.* 2014; Sayyed *et al.* 2016; Sayyed *et al.* 2018). However, there is still pending confusion demanding detailed investigation of the taxonomy of some Indian *Cnemaspis* species, which were described prior to 1984. For example, detailed descriptions, type localities, distribution data and incorrectly designated types of significant number of *Cnemaspis* are still notable causes of taxonomic confusion in the group. But those revisions are beyond the scope of present work and in the future it is expected that further revisions will provide new understanding about this cryptic genus. The new species described herein was previously misidentified as *C. ornata*. We have observed and examined fresh specimens including the type series of the new species during our field surveys at the type locality and in other parts of Tirunelveli, Tamil Nadu. In addition, the cluster analysis implies that *C. aaronbaueri* is morphometrically distinct. However, additional analyses using both morphometric data from more specimens and molecular data will bolster these results. Examination of museum specimens, notably the paralectotypes of *C. ornata* designated by (Manamendra-Arachchi *et al.* 2007), at the Natural History Museum, London (NHMUK) revealed some discrepancies with the lectotype. Careful examination of the types series of *C. ornata* revealed that NHMUK 74.4.29.401, NHMUK 74.4.29.404, NHMUK 74.4.29.405, NHMUK 74.4.29.406, NHMUK 74.4.29.407, NHMUK 74.4.29.408 and NHMUK 74.4.29.409 belong to *C. ornata*. Two other specimens, NHMUK 74.4.29.402 (female) and NHMUK 74.4.29.403 (male) represent *C. aaronbaueri* (Table 3). Description of yet another species of the genus *Cnemaspis* elevates the number of species within the genus to 36 from India. Additional undescribed taxa within the genus undoubtedly still remain. It is likely that extensive surveys in mainland India will yield further new discoveries and rediscoveries in the genus.

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APPENDIX 1. Specimens examined.

- Cnemaspis aijjiae*: BNHS 2456, ZSI WRC R/1054, ZSI WRC R/1056, ZSI WRC R/1057, ZSI WRC R/1059, ZSI WRC R/1060 (male), BNHS 2457, ZSI WRC R/1055 and ZSI WRC R/1058 (female), from the Satara, Maharashtra, India.
- Cnemaspis beddomei*: NHMUK 1946.9.4.83 (male), from South Tinnevely, Tirunelveli, southern Tamil Nadu State, India.
- Cnemaspis gracilis*: NHMUK 74.4.29.393 (male), from Palghat Hills” (Kerala State, India), BNHS 1182 (male), Goa, and BNHS 2513 and BNHS 2514, collected from the Palakkad, Kerala, for examination and used for genetic analysis.
- Cnemaspis indica*, NHMUK 46.11.22.22b (male), BNHS 1252-10 (male), Nilgiris, Tamil Nadu.
- Cnemaspis kolhapurensis*: BNHS 1855 (male), Dajipur, Kolhapur district, Maharashtra, and BNHS 2447, BNHS 2448, from Amboli, Sindhudurg district, Maharashtra, India.
- Cnemaspis maculicollis*: ZSI/WGRC/IR.V/2704 (male), from Pandimotta, Shendurney Wildlife Sanctuary, Kollam District, Kerala, India.
- Cnemaspis nilagirica*: NHMUK 74.4.29.729 (female), Nilgiris, Nilgiri District, Tamil Nadu State, south-western India.
- Cnemaspis ornata*: Lectotype NHMUK 74.4.29.400 (male), paralectotype NHMUK 74.4.29.401 (male), NHMUK 74.4.29.402 (female), NHMUK 74.4.29.403 (male), NHMUK 74.4.29.404 (female), NHMUK 74.4.29.405 (female), NHMUK 74.4.29.406 (female), NHMUK 74.4.29.407 (female), NHMUK 74.4.29.408 (female), NHMUK 74.4.29.409 (female), from South Tinnevely Hills, Tirunelveli, Tamil Nadu State, India.
- Cnemaspis sisparensis*: NHMUK 74.4.29.383 (male), from Sholakal, the foot of Sispara Ghat, Kerala, India.
- Cnemaspis wynadensis*: BMNH 74.4.29.355 (male), from Wynaad, Kerala, and BNHS 1042, BNHS 1043 (male), Mannarghat, Palghat, Kerala, India